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THE PRINCIPAL DIVISIONS AND GROUPS OF ENTEROBACTERIACEAE AND THEIR DIFFERENTIATION

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It is not the writers' purpose to attempt a review of the literature on taxonomy and nomenclature within the family Enterobacteriaceae[1]. It is wished to present only in outline a taxonomic system which we have found to be practical and which may be useful to others. The system outlined in the following pages is the result of many years of discussion and consideration on the part of the authors and it has been presented at a number of seminars, workshops, and informal discussions during the past few years. Also, persons primarily interested in taxonomy or nomenclature have expressed interest in the system because it is logical and can be directly transposed into a formal system of taxonomy and nomenclature consisting of tribes and genera by anyone interesting in so doing.

The system is presented in the nine tables that follow. The tables are self-explanatory and contain the essential information required in the differentiation of the various groups of Enterobacteriaceae. The reactions listed are those given by the majority of cultures but notes are included where necessary to explain certain important exceptions. The methods used in the determination of the biochemical reactivities of the microorganisms were those

[1]Those interested in reading further on these subjects are referred to the following publications, which contain discussions and extensive bibliographies: Borman, et al. (1944), Cowan (1956), Edwards and Ewing (1955), Kauffmann and Edwards (1952), and Kauffmann (1949, 1953, 1954, 1956, 1959). Also, Bergey's Manual, the Report of the International Enterobacteriaceae Subcommittee (1958), and a file of the International Bulletin of Bacteriological Nomenclature and Taxonomy should be consulted.

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which may be termed "recommended" or "standard" methods. A compilation of these methods is available upon request.

The family Enterobacteriaceae[1] is composed of a number of delineated groups of bacteria, each of which consists of types that give similar biochemical reactions. Some of these groups, or genera, are related to each other through the similarity of their biochemical reactions and, in many cases at least, by means of close antigenic relationships. For example, the Salmonella, Arizona and Citrobacter groups are related biochemically and may be said to belong to the same principal division. Similarly, the Shigella and Escherichia groups are more closely related to each other, both biochemically and serologically, than either is related to any other group, hence, are placed in another principal division. In the outline classification given herein, the authors have placed groups in the same principal division if the members of those groups possessed a number of common biochemical characteristics and have not relied upon any single characteristic, such as failure to ferment lactose, for this purpose. Therefore, the resulting taxonomic schema consists of only four principal divisions, each of which is composed of two or more groups. It is the writers' firm belief that this arrangement is more logical than certain classifications, which place quite different bacteria such as those of the Salmonella and Shigella groups in the same tribe simply because members of these groups usually fail to ferment lactose. It will be noted that the Serratia group has been incorporated into the Klebsiella-Aerobacter-Serratia principal division. This was done because the Serratiae have many properties in common with members of the Klebsiella and Aerobacter groups and because studies have indicated that there is no justification for a separate tribe Serratieae erected primarily upon pigment production.

It is well known that Enterobacteriaceae exist that may not be readily classified in one of the delineated groups, although the principal division to which such a culture belongs may be perfectly apparent. Such strains should be collected and studied carefully, since a collection of re-

[1]Definitions of the family may be found in the Reports of the International Enterobacteriaceae Subcommittee (1954, 1958).

lated biotypes may constitute a new group or subgroup. Or, a culture may be sui generis and another like it may not be seen again. To the authors the fact that occasional unclassifiable strains occur seems much less remarkable than the fact that the majority of cultures isolated daily in diagnostic work are perfectly typical and easily classified.

The principal divisions and groups are erected upon a biochemical basis and subgrouping within the various biochemical groups may be accomplished by means of further biochemical tests, on the basis of serology, or by a combination of both methods. Generally, the groups are subdivided on the basis of their O antigens as in the case of the Salmonella, Arizona, Citrobacter, Escherichia, Providence, and Serratia groups. The O antigen groups are further subdivided into serotypes, which are characterized by the possession of particular O antigen fractions, K (sheath or capsular) antigens, and H (flagellar) antigens. Further, some serotypes may be composed of two or more biotypes or bacteriophage types. Some biochemical groups are divided into subgroups by means of the biochemical and serological characteristics of the serotypes contained in each of the subgroups. For example, the Shigella group is composed of four subgroups, which are differentiated by means of the biochemical and serological characteristics of the serotypes contained in each. In the Klebsiella group, subdivision generally is made directly into capsular types by means of K antigen determination, although at least three principal biochemical subgroups also are recognized by many within the Klebsiella group. These correspond to the species Klebsiella pneumoniae, K. rhinoscleromatis, and K. ozaenae. If biochemically defined species are to be erected within this group, it is possible that the indol positive, gelatin positive Klebsiella oxytoca (Bacterium oxytocum Flügge) Lautrop 1956, should be included.

At present the Aerobacter group is divisible into three subgroups by means of biochemical characteristics. These subgroups correspond to the species Aerobacter cloacae, A. aerogenes, and A. liquefaciens Grimes (1931). No biochemical subgroups have been established within the Hafnia group since cultures studied to date are quite similar. It is the opinion of the authors that the biochemical interrelationships of Hafnia cultures and members of Aerobacter subgroups should be studied and further elucidated

before a final decision is made regarding the status of the Hafnia group and before generic status is assigned to it as suggested by Cowan (1956). Data presently available indicate that the Hafnia probably should be regarded as a subgroup of the Aerobacter group or perhaps simply as a biotype within one of the existing Aerobacter subgroups. It may be recalled that Stuart et al. (1943) considered cultures that now are called Hafnia as a subdivision of Aerobacter.

The authors have elected to retain the Rustigian and Stuart (1943, 1945) classification of the Proteus group and have placed the Proteus and Providence groups in the same principal division. However, reorganization within the Proteus-Providence division according to the suggestions made by Kauffmann (1953), by Ewing (1958), or according to other proposals may be desirable in future.

It may be noted that in the foregoing discussion of principal divisions nothing has been said about "the paracolon group." This omission was intentional, since in reality, there is no such thing as "a paracolon group." The term "paracolon" has been applied to a wide variety of bacteria, including certain salmonellae, and has lost any meaning it once may have had. Into a so-called "paracolon group" have been placed a large number of diverse microorganisms that have only one common differential characteristic: the inability to ferment lactose promptly. Each group of bacteria that ferments lactose promptly also includes counterparts that do not attack this substrate or do so only after prolonged incubation. Failure to ferment lactose should not exclude a culture from a group of which it is otherwise a typical member. An Escherichia strain and an Aerobacter culture should not be placed together in a "paracolon group" because each produces acid from lactose after some delay. Instead each should be classified in its appropriate group regardless of its reluctance to utilize lactose, particularly since the rate of lactose fermentation is not a stable characteristic. For example, a "Paracolobactrum coliforme" may be changed to Escherichia coli simply by selection of components that ferment lactose rapidly. Therefore, the writers do not believe that genera should be erected upon the single characteristic of failure to ferment lactose. Hence, we cannot accept the genus Paracolobactrum (Bergey's Manual, 7th ed.) in which totally different microorganisms are placed together simply because of their re-

luctance to utilize lactose. Parenthetically, it may be added that the International Enterobacteriaceae Subcommittee does not recognize the genus Paracolobactrum nor the paracolobactrum group (Minutes of Subcommittee Meetings, Stockholm, 1958). At the risk of being repetitious we shall state again that the group to which a microorganism belongs must be determined by a combination of biochemical reactions, not by a single property. Only in this manner can an orderly arrangement of biochemical groups within the family be achieved.

Table 1. The Principal Divisions and Groups of Enterobacteriaceae.

Principal Divisions	Groups
Shigella - Escherichia	Shigella Escherichia (E. coli, including Alkalescens-Dispar)
Salmonella - Arizona - Citrobacter*	Salmonella Arizona Citrobacter* (including Bethesda-Ballerup)
Klebsiella - Aerobacter - Serratia	Klebsiella Aerobacter Hafnia Serratia
Proteus - Providence	Proteus Providence

*Formerly Escherichia freundii.

Table 2. Differentiation of the Principal Divisions Within the Enterobacteriaceae by Biochemical Methods (Reactions of Typical Cultures)

Substrate or Test	Shigella - Escherichia Division	Salmonella - Arizona - Citrobacter Division	Klebsiella - Aerobacter - Serratia Division	Proteus - Providence Division
Indol	d	-	-	d
Methyl-red	+	+	-	+
Voges-Proskauer	-	-	+	-
Simmons' citrate	-	+	+	d
Hydrogen sulfide (TSI)	-	+	- or (+)	d
Urease	-	-	- or (+)	d
KCN	-	d	+	+
Phenylalanine	-	-	-	+

N.B. S. typhi, S. paratyphi A and some of the rare types are citrate negative. S. paratyphi and other rare types are H_2S negative.

+ = positive in one or two days.
- = negative.
(+) = delayed positive.
d = different biochemical types.

Table 3. The Shigella-Escherichia Division.

Substrate or Test	Shigella Group	Escherichia Group
Gas from glucose	-*	+ (-)
Lactose	-*	+ or x
Salicin	-	d (approx. 80% +)
Motility	-	+ (-)
Lysine decarboxylase	-	+
Mucate	-	+ (-)
Christensen's citrate	-	+ (-)

*Certain biotypes of S. flexneri 6 form gas and S. sonnei cultures ferment lactose slowly.

N.B. There is no difficulty in the differentiation of typical E. coli cultures and shigellae. However the anaerogenic nonmotile, varieties of E. coli, some of which are often referred to as Alkalescens-Dispar types, may require closer examination before they can be definitely classified as E. coli. In attempting to classify a particular strain as E. coli or as a member of the Shigella group, the biochemical reactivities of the culture should be considered as a whole. Shigellae are much less reactive than E. coli strains and a culture that produces acid promptly (i.e., within 24 hrs.) from all, or most of a wide variety of carbohydrates, such as maltose, rhamnose, xylose, sorbitol, and dulcitol, undoubtedly is not a member of the Shigella group.

\+ positive in one or two days.
\- negative.
\+ (-) majority of strains positive, negative varieties occur.
x late and irregularly positive.
d different biochemical types.

Table 4. The Salmonella - Arizona - Citrobacter Division

Substrate or Test	Salmonella Group	Arizona Group	Citrobacter Group
Lactose	-	+ or x	+ or x
Dulcitol	+	-	d
Gelatin	-	(+)	-
KCN	-	-	+
Lysine decarboxylase	+	+	-
Malonate	-	+	-

N.B. The majority of salmonellae ferment dulcitol promptly, but S. typhi, S. pullorum, S. paratyphi A, S. choleraesuis, and a few others do not do so. Members of the Arizona group are uniformly negative on this substrate. S. paratyphi A is lysine negative.

\+ positive in one or two days.

\- negative.

(+) delayed positive.

x late and irregularly positive.

d different biochemical types.

Table 5. The Salmonella - Arizona - Citrobacter Division Reactions in Organic Acid Media[1]

Substrate or Test	Salmonella	Arizona	Citrobacter
Mucate	+	- (+)	+
D-tartrate	+	-	-
Citrate	+	-	-
Malonate	-	+	-

[1]Organic acids as used by Kauffmann and Petersen (1956) and by Ellis, Edwards and Fife (1957).

N.B. The reactions given in Table 5 are the "pattern reactions" given by the majority of strains belonging to the three groups. Occasional strains may give a slightly different pattern and the publications quoted should be consulted when exceptional results are obtained.

\+ positive in one or two days. - negative.
- (+) majority of strains negative, occasional strains positive.

Table 6. The Klebsiella - Aerobacter - Serratia Division

Substrate or Test	Klebsiella and Aerobacter Groups	Hafnia Group 37°C	Hafnia Group 22°C	Serratia Group
Gas from glucose	+	+	+	d
Gas from cellobiose	+	+	+	-
Gas from glycerol	d	+	+	-
Sorbitol	+	-	-	+
Methyl red	-	+	-	-
Voges-Proskauer	+	d	+	+
Gelatin	d		-	+

N.B. When gas is formed from glucose by Serratia, the volumes are small (10% or less).
\+ = positive in one or two days. - = negative.
d = different biochemical types.

Table 7. The Klebsiella - Aerobacter - Serratia Division

Substrate or Test	Klebsiella Group	Aerobacter Group Subgp. A	Aerobacter Group Subgp. B	Hafnia Group 37°C	Hafnia Group 22°C	Aerobacter Group Subgp. C 37°C	Aerobacter Group Subgp. C 22°C	Serratia Group
Gas from glucose	+	+	+	+	+	+	+	d
Gas from inositol	+	-	+	-	-	+	+	-
Gas from glycerol	+	-	+	+	+	d	(+)	-
Gas from cellobiose	+	+	+	+	+	d	(+)	-
Sorbitol	+	+	+	-	-	+	+	+
Raffinose	+	+	+	-	-	+	+	-
Lysine decarboxylase	+	-	+	+	+	d	+	+
Arginine dihydrolase	-	+	-	-	-	-	-	-
Ornithine decarboxylase	-	+	+	+	+	+	+	+
Gelatin	-	(+)	x		-		+	+
Motility	-	+	+	d	+	+	+	+

N.B. When gas is formed from glucose by Serratia, the volumes are small (10% or less).
Aerobacter Subgroup A corresponds to Aerobacter cloacae.
Subgroup B corresponds to Aerobacter aerogenes.
Subgroup C corresponds to Aerobacter liquefaciens (a psychrophilic bacterium).

\+ positive in one or two days. - negative. (+) delayed positive.
x late and irregular positive. d different biochemical types.

Table 8. Differentiation of Aerobacter subgroup C and the Hafnia and Serratia Groups.

Substrate or Test	Aerobacter Group Subgroup C 37°C	Aerobacter Group Subgroup C 22°C	Hafnia Group 37°C	Hafnia Group 22°C	Serratia Group
Gas from glucose	+	+	+	+	d
Gas from glycerol	d	(+)	+	+	-
Gas from inositol	+	+	-	-	-
Gas from cellobiose	d	(+)	+	+	-
Sorbitol	+	+	-	-	+
Arabinose	+	+	+	+	-
Raffinose	+	+	-	-	-
Rhamnose	-	-	+	+	-
Gelatin		+		-	+

N.B. When gas is formed from glucose by Serratia, the volumes are small (10% or less).

\+ positive in one or two days. - negative.
(+) delayed positive. d different biochemical types

Table 9. The Proteus - Providence Division

Substrate or Test	Proteus Group vulgaris	mirabilis	morganii	rettgeri	Providence Group
Mannitol	-	-	-	+	d
Indol	+	-	+	+	+
Simmons' citrate	d	d	-	+	+
Hydrogen sulfide (TSI)	+	+	-	-	-
Gelatin	+	+	-	-	-
Urease	+	+	+	+	-

\+ positive in one or two days. - negative.
d different biochemical types.

REFERENCES

Bergey's Manual of Determinative Bacteriology. Edited by Breed, R.S., E.G.D. Murray and A.P. Hitchens. 7th Ed. 1957. Williams and Wilkins, Baltimore.

Borman, E.K., C.A. Stuart and K.M. Wheeler. 1944. J. Bact. 48:351.

Cowan, S.T. 1956. J. Gen. Microbiol. 15:345.

Edwards, P.R. and W.H. Ewing. 1955. Identification of Enterobacteriaceae. Burgess, Minneapolis.

Ellis, R.J., P.R. Edwards and M.A. Fife. 1957. Public Health Lab. 15:89.

Ewing, W.H. 1958. Internat'l. Bull. Bact. Nomen. and Taxon. 8:17.

Grimes, M. 1931. Sci. Proc. Roy. Dublin Soc. 20(NS):89.

Kauffmann, F. 1949. Acta Path. Microbiol. Scand. 26:879.

____. 1953. Riv. Inst. Sieroter, Ital. 28:484.

____. 1954. Enterobacteriaceae. 2nd Ed. Einar Munksgaard, Copenhagen.

____. 1956. Zentrabl. f. Bakt., I Orig. 165:344.

____. 1959. Internat'l. Bull. Bact. Nomen. and Taxon. 9:1.

____ and P.R. Edwards. 1952. Internat'l. Bull. Bact. Nomen. and Taxon. 2:2.

____ and A. Petersen. 1956. Acta Path. Microbiol. Scand. 38:481.

Lautrop, H. 1956. Acta Path. Microbiol. Scand. 39:375.

Minutes of International Enterobacteriaceae Subcommittee Meetings, Stockholm. 1958. Internat'l. Bull. Bact. Nomen. and Taxon. 8:173.

Reports, International Enterobacteriaceae Subcommittee, 1954, 1958. Internat'l. Bull. Bact. Nomen. and Taxon, 4:194 and 8:25.

Rustigian, R. and C.A. Stuart. 1943. Proc. Soc. Exptl. Biol. Med. 53:241.

Stuart, C.A., K.M. Wheeler, R. Rustigian and H. Zimmermann. 1943. J. Bact. 45:101.

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COMMITTEE ON TERMINOLOGY IN BIOLOGICAL NOMENCLATURE OF THE INTERNATIONAL UNION OF BIOLOGICAL SCIENCES

R. E. Buchanan
Iowa State University

Workers in microbiology find that the pure culture techniques originally developed in bacteriology are increasingly useful in study of many microorganisms other than bacteria. In the microbiological laboratory these techniques are employed in the study of bacteria, viruses, algae (usually unicellular or filamentous), fungi (usually yeasts and hyphomycetes), and protozoa. The microbiologist is concerned with three disciplines, botany, zoology, and bacteriology (including virology). He uses the nomenclatures of the three. Each discipline has its own international nomenclatural code, each code differing in some respects from the other two. He finds differences in terminology in the several codes which make difficult his microbiological nomenclature. Increasingly each of the three disciplines is concerned with the nomenclature of the others.

The XIII General Assembly of the International Union of Biological Sciences, at its London meeting in July, 1959, considered this problem. It received and approved the following proposal:

1. That this Union authorize the formation of an ad hoc Committee on Terminology in Biological Nomenclature.
2. That the Committee be constituted by asking each of the three international commissions to appoint (or nominate) two members.
3. That the Committee be asked to consider and report on possibilities of reconciliation of differing terminologies in the several International Codes of Biological Nomenclature.

The minutes state:

> "(1) that after a discussion in which various members of the Assembly participated the Assembly decided to set up an ad hoc committee on terminology and Biological Nomenclature. The Committee will be

composed by two members of the three International Commissions on Nomenclature, namely: Botanical, Zoological and Microbiological. The six persons so appointed may coopt a seventh member. The Committee will report at the next General Assembly"

The members of the Committee appointed are:

Representing Botany

Professor J. Lanjouw, University of Utrecht, 106 Lange Nieuwstraat, Utrecht, Netherlands. Chairman.
Dr. A.C. Smith, Smithsonian Institution, Washington, D.C.

Representing Zoology

Professor J.R. Dymond, Department of Zoology, University of Toronto, Toronto 7, Ontario, Canada.
Professor E. Mayr, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.

Representing Microbiology

Dr. J. Ramsbottom, 34 Ennerdale Road, Richmond, Surrey, England.
Professor R. E. Buchanan, Room 316 Curtiss Hall, Iowa State University, Ames, Iowa, U.S.A.

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A meeting of the I.U.B.S. Committee on Terminology in Biological Nomenclature was held during the sessions of the IX Botanical Congress on Saturday, August 22nd, 1959, in Montreal.

All members were present or represented except Dr. Ramsbottom who was unable to attend. Dr. Lanjouw presided at the meeting. There was substantial agreement that a study of terminological differences among the three codes of biological nomenclature would be rewarding. Some of the differences perhaps may be eliminated, at least they can be accurately defined. Certainly this is true in use of different words for the same concept and in definition of terms and the use of the same term with one

meaning in one code and a quite different meaning in another code. There are also some differences in philosophy which possibly cannot be reconciled, but at least can be defined. It was pointed out that a microbiologist may, by use of the special techniques developed in bacteriology, be involved in problems of nomenclature involving bacteria, viruses, lower fungi, yeasts, algae and protozoa. He must use each of the three codes if he is to be nomenclaturally literate. But he finds that the word valid when used in the Zoological Code has quite a different connocation than when used in the Botanical or Bacteriological Codes. A "legitimate" name in bacteriology is an "available" name in zoology.

Agreement was reached as to procedure in the immediate future.

1. Dr. Mayr will study the Zoological Code and list terms and definitions that are there used and of general biological interest. These will be annotated and sent to the chairman.
2. Professor Buchanan in consultation with Dr. Ramsbottom will gather the pertinent material from the Bacteriological Code and transmit it to Dr. Lanjouw.
3. Dr. Lanjouw will assume the responsibility of gathering the significant material from the Botanical Code. He will receive and edit the material submitted from all three codes.
4. A comparison of differences in definitions and terminologies may lead to proposals for use of some of the same terms in the several codes.
5. A proposal that was favorably discussed was to prepare a glossary which would include a complete list of the significant terms used in all of the codes, with equivalences and special uses clearly developed.
6. In the glossary there might well be some discussion of the differences in basic nomenclatural philosophy.

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CHEMICAL TERMINOLOGY AND MICROBIOLOGICAL NOMENCLATURE

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The descriptions of most species of bacteria and yeasts, of many of the filamentous fungi and of some of the protozoa include criteria based upon physiology and relationships to chemical elements and compounds. Frequent reference to chemical changes produced by microorganisms and to the influence of chemical environments upon the cells has led to the proposal of names of bacterial taxa, particularly of generic names and of species (specific epithets), which have some chemical connotation. Etymologically some of the names proposed are good, others are ambiguous, still others are improperly formed. The problem of developing names of taxa and of epithets not only acceptable (legitimate) but etymologically defensible is not particularly difficult of solution, but a search of the literature of nomenclature has disclosed no adequate presentation of the special problem of Latinizing chemical names for use in forming words to be used as names of taxa or as specific epithets, particularly in microbiology.

Many generic names and specific epithets are based upon the Latin or Latinized names of chemical elements or compounds. The index to the seventh edition of Bergey's Manual of Determinative Bacteriology includes 75 names of bacterial genera that have some chemical connotation. This list as here given is by no means inclusive.

Names of Genera. Acetobacter, Acetobacterium, Acetomonas, Aerobacter, Alcaligenes, Alginobacter, Alginomonas, Azotobacter, Azotomonas, Butyribacterium, Carboxydomonas, Caseobacterium, Cellfalcicula, Cellulomonas, Cellvibrio, Citrobacter, Cytophaga, Desulfovibrio, Ferribacterium, Ferrobacillus, Halobacter, Halobacterium, Halococcus, Halophilus, Hydrogenomonas, Hygrocrocis, Lactobacillus, Lactobacterium, Lactococcus, Methanobacterium, Methanococcus, Methanomonas, Methanosarcina, Nitrobacter, Nitrocystis, Nitrogloea, Nitrosococcus,

Nitrosocystis, Nitrosogloea, Nitrosomonas, Nitrosospira, Pectobacterium, Peptococcus, Peptostreptococcus, Propionibacterium, Protaminobacter, Saccharobacillus, Saccharobacterium, Saccharomonas, Siderobacter, Siderocapsa, Siderococcus, Siderocystis, Sideroderma, Sideromonas, Sideronema, Siderophacus, Siderosphaera, Sidero-thece, Sporocytophaga, Sulfomonas, Sulfospirillum, Thiobacillus, Thiobacterium, Thioderma, Thiophysa, Thioploca, Thiosphaerella, Thiospira, Thiospirillopsis, Thiothrix, Thiovibrio, Thiovulum, Urobacillus, Urococcus, Urosarcina.

There are also many specific epithets which are derived from Latin or are Latinized words (or phrases) denoting chemical elements or compounds. The following list of 109 such specific epithets is also taken from the Bergey Manual Index. It is illustrative, but not complete. Nouns used as specific epithets are listed in the nominative singular, adjectives are given in nominative masculine singular.

Words and phrases used as specific epithets. aceticus, acetus, acetobutylicus, acetosus, acetylicus, acidum-lacticum, acidum-uricum, acidofaciens, acidominimus, acidophilus, acidulus, aerofaciens, aerofoetidus, aerogenes, aerogenoides, alcalescens, alginicus, alginovorus, ammoniagenes, amylifer, amylolyticus, amylosaccharobutylpropionicus, amylovorus, antibioticus, asaccharolyticus, biazoteus, butylicus, butyrum, butyricus, calx, caseus, caseolyticus, cellaseus, cellobioparus, cellulo-flavus, conjac, coproliticus, creatinovorans, cremor, cytophagus, denitrificans, desulfuricans, dextranicus, diastaticus, diastatochromogenes, ethylicus, farinosus, felsineus, ferrooxidans, ferrugineus, gazogenes, gelaticus, glycinophilus, gylcolyticus, halobius, halodenitrificans, halohydrius, halonitrificans, halosmophilus, hydrophilus, hydrosulfureus, hygroscopicus, indol, indologenes, indol-oxidans, iodinum, iodophilus, iophagus, lactoacetophilus, lipoferus, lipolyticus, lipophagus, melaninogenicus, metabotulinus, metalcaligenes, methanicus, nitritogenes, nitrogenes, nitrosus, oleovorans, oligocarbophilus, oxaliferus, oxalaticus, oxydans, pectinovorus, propionicus, proteamaculans, proteiformis, reducans, saccharolyticus, sideropous, suboxydans, succinogenes, sulfureus, sulphuricus,

thermocellulaseus, thermocellus, thermodiastaticus, thiogenes, thiooxidans, thioparus, thiosulfatophilus, tyrobutyricus, urea, ureafaciens, ureasophorus, urealyticus, urina.

In many cases the stems of the names of genera and of the specific epithets are from Latin or Greek. Mediaeval Latin made some contributions, but in most cases the words are Neo-Latin, formed frequently from vernacular words.

Much of the information needed for formulating new names and epithets can be found in the Neo-Latin discussed in texts on use of Latin and Greek in pharmacology. Until recent years physicians wrote their prescriptions in modern Latin, and drugs and pharmaceuticals were given Latin names. Most of the rules and conventions now used were developed with the rapid advances in pharmacology and medicine. The names and rules for their formation are still appropriate and useful. Herewith are listed some of the more important groups of the vernacular English names of chemical elements, compounds and radicals with their Latin or Neo-Latin equivalents which are available for use in coining new names of taxa in the field of microbiology.

The Latin, mediaeval Latin and Neo-Latin names of chemical elements, compounds and drugs are:

I. (Occasionally) feminine nouns in the first declension, with nominative in -a.
II. (Rarely) masculine nouns in the second declension, with nominative in -us.
III. (Commonly) neuter nouns in the second declension, with nominative in -um.
IV. (Some) neuter nouns in the third declension (imparisyllabic) with nominative in -ol, -al, -er, or -yl.
V. (Some) masculine nouns in the third declension (imparisyllabic) with nominative in -is or -as.

I. Feminine nouns of first declension with nominative in -a, genitive -ae.

a. Names of drugs found in classical or mediaeval Latin. There are classic or mediaeval Latin equivalents of modern names for certain drugs, as gentian = gentiana, ae, Latin feminine noun; camphor = camphora, ae, mediaeval Latin feminine noun.

b. Modern Latin names of drugs formed by adding -a to the vernacular name, as ergot = ergota, ae, Neo-Latin feminine noun, from the French ergot.

c. Names of alkaloids and other organic bases. These end in -ine in English. In Neo-Latin they are feminine nouns in the first declension and end in -ina.

aconitine = aconitina, ae; morphine = morphina, ae; atropine = atropina, ae; quinine = quinina, ae; cocaine = cocaïna, ae; amine = amina, ae.

Some older pharmacopoeias give the ending -ia instead of -ina, as strychnine = strychnia, ae; morphine = morphia, ae.

d. Names of compounds which in the vernacular end in -a.

urea = urea, ae.

II. Masculine nouns of second declension with nominative in -us, genitive -i.

These are not common. The name of the element phosphorus belongs here.

phosphorus = phosphorus, i.

siderus, i = Greek σίδερος = iron.

III. Neuter nouns in the second declension with nominative in -um, genitive -i.

a. Names of chemical elements. All except sulfur and phosphorus are neuter second declension nouns end-in in -um. Not all end in -um in the vernacular. The Latin or Neo-Latin Names of some of the elements that in English do not end in -um are here listed:

antimony = antimonium; arsenic = arsenum; bismuth = bismuthum; boron = borum; bromine = bromum; carbon = carboneum (also carbo, carbinis); chlorine = chlorum; cobalt = cobaltum; copper = cuprum; fluorine = fluorum; gold = aurum; hydrogen = hydrogenum; iodine = iodinum; iron = ferrum (see also siderus); lead = plumbum; manganese = manganum; mercury = hydrargyrum; nickel = nicolum; nitrogen = nitrogenium; (the Greek derived French azote becomes azotum, i); oxygen = oxygenium; potassium = kalium; silicon = silicum; silver = argentum; tin = stannum; tungsten = wolframium; zinc = zincum.

b. Certain "neutral principles" (of the pharmacist), which in English end in -in, in Neo-Latin are neuter nouns of the second declension and end in -um, i.

aloin = aloinum, i; salicin = salicinum, i; saponin = saponinum, i.

c. The names of anions which in English end in -ide (or -id) in Neo-Latin have the ending -idum; they are neuter nouns of the second declension.

oxide = oxidum; calcium oxide = calcii oxidum; cyanide = cyanidum; potassium cyanide = potassii cyanidum; sulfide = sulfidum; sodium sulfide = sodii sulfidum.

d. Acid = Neo-Latin acidum, neuter noun of the second declension, from the Latin adjective acidus = sour. Acids are named by use of acidum followed by a descriptive neuter adjective. The corresponding English adjective usually ends in -ous or -ic, the Neo-Latin ends in -osum, or -icum.

acetic acid = acidum aceticum, acidi acetici; nitric acid = acidum nitricum, acidi nitrici; nitrous acid = acidum nitrosum, acidi nitrosi; oleic acid = acidum oleicum, acidi oleici; sulfurous acid = acidum sulfurosum, acidi sulfurosi.

e. Chemical compounds which in English have the endings -ane, -ene, or -one in Neo-Latin are second declension neuter nouns ending respectively in -anum, -enum, or -onum.

ethane = ethanum, i; ethylene = ethylenum, i; ketone = ketonum, i; lactone = lactonum, i; propane = propanum, i.

f. Carbohydrates (monosaccharides) usually have English names ending in -ose. Neo-Latin names end in -osum and are neuter nouns in the second declension.

cellobiose = cellobiosum, i; cellulose = cellulosum, i (occasionally cellulosa, ae.); dextrose = dextrosum, i; sucrose = sucrosum, i; xylose = xylosum, i.

In general the base or combining form to be used in making names of bacterial taxa from Neo-Latin words is found by dropping the ending of the genitive singular. In a few cases the chemical usage of abbreviating this base has been followed. This may be illustrated by the treatment accorded cellulose in chemistry and bacteriology. Hydrolysis of cellulose yields, as the

constituent building block of the polymer, the disaccharide named cellobiose instead of the more logically formed cellulosibiose. The shortened base cell- instead of cellulos- has been used in several bacterial generic names as Cellvibrio and Cellfalcicula.

g. The English names of complex carbohydrates (polysaccharides with the exception of cellulose), usually end in -an, the name commonly derived from the name of the simple carbohydrate of which the complex is a polymer, as dextran from dextrose. The Neo-Latin equivalent is formed by adding the ending -um, the name being a neuter noun in the second declension.

dextran = dextranum, i; galactan = galactanum, i; xylan = xylanum, i.

h. Organic compounds which are not alcohols whose names in English end in -ol, in Neo-Latin add -um and are neuter nouns in the second declension.

indol = indolum, i; iodol = iodolum, i (sometimes indol, indolis see IVa.); safrol = safrolum, i.

i. The English names of many enzymes have the ending -ase. The Neo-Latin equivalent ends in -asum and is a neuter noun of the second declension.

catalase = catalasum, i; coagulase = coagulasum, i; urease = ureasum, i.

IV. Neuter nouns in the third declension (imparisyllabic) in -ol, -ur, -al, -er and -yl.

a. The approved (standard) chemical names of alcohols in English usually end in -ol. Classic Latin nouns which end in -ol are almost nonexistent. Gradenwitz lists one only, sol, solis = the sun. In Neo-Latin the nominative of the name of an alcohol is the same as in English, and is regarded as a neuter noun ending in -ol, with genitive -olis.

alcohol = alcohol, alcoholis; citrinellol = citrinellol, citrinellolis; dulcitol = dulcitol, dulcitolis; ethanol = ethanol, ethanolis; glycerol = glycerol, glycerolis; phenol = phenol, phenolis.

Indole, though not an alcohol, has been sometimes placed here, indole = indol, indolis as in Clostridium indolis.

b. The name of the element sulfur* = sulfur, is, is a Latin neuter noun of the third declension. The Greek stem thi from θειον = thium, i = sulfur is also frequently used.

c. The English names of aldehydes and of some other organic compounds end in -al. The nominative in Neo-Latin is the same as in English. These names are regarded as neuter nouns in the third declension. They are imparisyllabic.
acetal = acetal, acetalis; chloral = chloral; chloralis.

d. The English names of certain organic compounds end in -er. The nominative in Neo-Latin is the same as in English. These names are regarded as neuter nouns in the third declension.
aether (ether) = aether (ether), aetheris (etheris); ester = ester, esteris.

e. Organic radicals with English names ending in -yl have the Neo-Latin nominative as in English. They are regarded as third declension neuter nouns.
butyl = butyl, butylis; ethyl = ethyl, ethylis.

V. Names of compounds or anions that in English end in -ite or -ate. Masculine nouns of the third declension.

a. The names of anions and compounds which in English end in -ite in Neo-Latin end in -is (genitive -itis).
arsenite = arsenis, arsenitis; sodium arsenite = sodii arsenis; nitrite = nitris, nitritis; calcium nitrite = calcis nitris.

b. The names of anions and compounds which in English end in -ate have the Neo-Latin ending -as, -atis.
acetate = acetas, acetatis; sodium acetate = sodii acetas; phosphate = phosphas, phosphatis; potassium phosphate = kalii phosphas; nitras, nitratis (the commonly accepted combining form is nitro).

c. The name of the element calcium = calx, calcis.

*The spelling approved by the American Chemical Society for the element corresponds to the classic Latin sulfur. The conventional British spelling is sulphur. This late Latin is given as an alternative spelling. Sulphur, is is also a Latin neuter noun of the third declension.

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MORAXELLA SOME PROBLEMS OF TAXONOMY AND NOMENCLATURE

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The genus Moraxella as treated in the 7th edition of Bergey's Manual (1957) comprises only 3 species, M. lacunata, M. liquefaciens and M. bovis. In addition to these, various other organisms have been described as Moraxella species. It is the purpose of this paper to examine the case for or against admission of some of these organisms to the genus as well as to discuss some questions of nomenclature.

In a previous paper (Henriksen 1952) it was shown that, in addition to morphology, the oxidase reaction, penicillin sensitivity and preference for a humid atmosphere could be used as criteria in the classification of Moraxella. Further experience has confirmed the usefulness of these criteria, in particular the two former, and has further indicated that some strains of Moraxella are sensitive to other antibiotics which are mainly active on Gram-positive bacteria and on Neisseria, viz. erythromycin and bacitracin. In addition to this it may be pointed out that all species of Moraxella recognized so far, and some which may deserve recognition, appear to have been isolated exclusively from mucous membranes of man or animals.

Nothing needs to be said in this place about M. lacunata or M. liquefaciens, as their recognition as separate taxa can be taken for granted. As for M. bovis, early descriptions (Jones and Little 1923) as well as the cytological studies of Murray and Truant (1954) indicate that it is morphologically a typical Moraxella. Barner (1952) found that this organism shows some degree of sensitivity to penicillin, bacitracin, chloramphenicol, dihydrostreptomycin and terramycin. A study of 4 strains (strains 8561, 9425 and 9426 from the National Collection of Type Cultures in London and strain 10900, one of Barner's strains, from the American Type Culture Collection) confirmed that these

strains are morphologically indistinguishable from Moraxella duplex var. nonliquefaciens (Lwoff 1939). Furthermore, they all showed a strong oxidase reaction with dimethylparaphenylenediamine, and tests by the disk method of Ericsson, Högman and Wickman (1954) showed that they were all highly sensitive to bacitracin, erythromycin, streptomycin, chloramphenicol and oxytetracycline. Two strains were highly sensitive to penicillin (inhibition zones of 31 mm and 34 mm), the other two moderately sensitive (zones of 25 and 28 mm). Two strains were highly sensitive and two resistant to sulphathiazole. There can be no doubt that this organism should be included in Moraxella, and that fact that it produces haemolysis on blood agar in contrast to the other species, justifies its claim for separate recognition.

The diplobacillus described by Scarlett (1916) and named Moraxella duplex var. nonliquefaciens by Lwoff (1939) has not yet been included in Bergey's Manual, but there can hardly be any doubt that this organism is just as worthy of recognition as any other Moraxella. It has been shown (Henriksen 1958, Kaffka 1959) that this organism is a very common inhabitant in the upper respiratory tract of man, and that it possesses all the characteristics of Moraxella, including typical morphology, oxidase reaction and penicillin sensitivity. It differed from other Moraxellae in failing to liquefy coagulated serum and gelatin, and therefore should be recognized as a separate species.

Lwoff (1939) recognized an additional variety of M. duplex, the variety josephi, likewise originally described by Scarlett (1916). This organism was Gram-positive, only a single strain was studied, it has never been encountered again, and the original description is rather sketchy. There can be no good reason to maintain this organism as a separate species or variety, unless it should be rediscovered.

Audureau (1940) described a new species, Moraxella lwoffi, divided into the varieties brevis and bacteroides, and later Piéchaud, Piéchaud and Second (1951, 1956) added still another variety, var. glucidolytica, later raised to the rank of species, M. glucidolytica, apparently identical with Bacterium anitratum of Schaub and Hauber (1948). It was shown in a previous paper (Henriksen 1952) that representative strains of these species showed little resemblance to Moraxella. Brisou and his collaborators (Brisou 1953,

1957a, 1957b, 1958; Bourlat 1953; Brisou and Morichaud-Beauchant 1952; Brisou, Morichaud-Beauchant and Giminez 1953; Brisou and Prévot 1954) arrived at similar conclusions and classified these organisms in Pseudomonadaceae, tribus Achromobactereae, genus Acinetobacter under the names A. lwoffi and A. anitratum. It is felt that this reclassification settles the dispute about the relationship of these organisms to Moraxella, as well as the question about the validity of the tribe Mimeae of De Bord.

Audureau (1940) also described a new variety of M. lacunata var. atypica, which differed from M. lacunata in failing to liquefy serum. Since otherwise only morphological criteria, which have proved unreliable in other cases, were used, it may be suggested that this organism should be re-examined before its relationship to Moraxella is determined.

Flamm (1956) described a strain of diplobacilli, isolated from spinal fluid, which he considered a new species of Moraxella, M. saccharolytica. The description indicates that this strain resembled Moraxella morphologically and possessed several additional Moraxella characteristics (oxidase reaction, penicillin sensitivity), but it differed from other Moraxellae in decomposing certain sugars with development of an acid reaction. The antibiogram showed by the strain was rather unusual with sensitivity to penicillin, polymyxin and supronal, and resistance to streptomycin, chloromycetin and tetracyclines. Apart from some hesitation in recognizing a new species on the basis of a single strain, it appears that this may be a new species, and that the name proposed by Flamm is correct. The strain should, however, be deposited in one of the type culture collections, unless this has already been done.

Finally Flamm (1957) described still another strain from a case of meningitis, believed to be a new species, M. polymorpha. This organism appeared to be a typical Moraxella in most respects, but it was characterized by a very marked pleomorphism and refused to grow in broth without the addition of serum. As for pleomorphism, this is a common characteristic of Moraxella. Thus pleomorphic strains of M. nonliquefaciens have been described by Murray and Truant (1954) and by the author (1958). In view of the fact that it appears that the strain did grow on plain nutrient agar without serum, it is felt that the need for

serum in broth can not be worthy of taxonomic recognition. Murray and Truant (1954) described a strain which showed unusual nutritional requirements in early cultures, but later was adapted to simple media. It seems probable that Flamm's strain may have been a slightly unusual strain of M. nonliquefaciens.

In conclusion, the organisms described as M. lacunata, M. liquefaciens, M. bovis, M. duplex var. nonliquefaciens and, with some hesitation, M. saccharolytica should be placed in different taxa in the genus Moraxella. M. lwoffi with the varieties brevis, bacteroides and glucidolytica do not belong in this genus. M. lacunata var. atypica should be re-examined before it is accepted, and M. polymorpha is considered to belong to M. duplex var. nonliquefaciens.

Turning to questions of taxonomy and nomenclature, none of the early names used in the original descriptions appear to be legitimate, and the first successful attempt to group and name these organisms is due to Lwoff (1939). In the absence of previous valid names, it would appear that the names proposed by Lwoff are valid and remain so, unless definite action is taken to change his system of classification.

Three different courses of action seem to be possible. First one might follow Lwoff's proposal and maintain the two species M. lacunata and M. duplex, the latter subdivided into the varieties liquefaciens and nonliquefaciens. The variety josephi should not be recognized, but var. bovis should be added as a new variety, as suggested by Lwoff. M. saccharolytica could be added as a third species as proposed by Flamm, since the faculty of decomposing sugars may be of some taxonomic significance. The rules of nomenclature and reasons of priority would appear to be in support of this alternative. On the other hand the division of bacterial species into varieties is not very common, and no practical advantage is gained by considering these organisms as varieties of the same species and not as separate species. Furthermore, it is difficult to understand why greater taxonomic significance should be attached to the need for serum (actually probably only a question of neutralization of some toxic component of the usual media) than to the faculty of digesting solid proteins.

Second, one might consider all the Moraxellae recognized so far (with the possible exception of M. saccharolytica) as

a single species, M. lacunata with the varieties liquefaciens, nonliquefaciens and bovis. There may be little to be said in support of this plan, except that it is simple and takes the close similarity of the Moraxella strains into consideration. The differences may be rather slight to justify separation into different species.

Third, one might give all these organisms the rank of species, M. lacunata, M. liquefaciens, M. nonliquefaciens, M. bovis and M. saccharolytica. This may be the simplest solution and the one that is in the closest conformity to the usual principles and customs of classification. It meets the practical need for separation of different organisms in different taxa, without making any distinction between the relative taxonomic significance of different types of criteria. And it would always be possible to change the system at some later date, if future studies should show that this was desirable. But, in view of what has been said above, it is felt that this course of action could only be taken if the International Committee formally decides to do so and to set previous proposals for the classification of this group aside. It is the opinion of the present author that such action would be desirable.

SUMMARY

It is proposed that the genus Moraxella should be divided into the species M. lacunata, M. liquefaciens, M. nonliquefaciens and M. bovis, and that the recognition of M. saccharolytica as a new species should be considered.

REFERENCES

Audureau, A. 1940. Ann. Inst. Pasteur. 64:126.

Barner, R.D. 1952. Amer. J. Vet. Res. 13:132.

Bourlat, R. 1953. Contribution a l'étude bactériologique de "B. anitratum" et des germes voisins. Leur position dans la systématique. Imprimerie E. Brouillard, Bordeaux.

Breed, R.S., E. G. D. Murray and N.R. Smith. 1957. Bergey's Manual of Determinative Bacteriology. 7th edition.

Brisou, J. 1953. Ann. Inst. Pasteur. 84:812.

____. 1957a. Ann. Inst. Pasteur. 92:134.

_____. 1957b. Ann. Inst. Pasteur 93:397.
_____. 1958. Étude de quelques Pseudomonadaceae. Classification. Imprimerie A. Baillet, Bordeaux.
_____ and J. Morichaud-Beauchant. 1952. Ann. Inst. Pasteur 82:640.
_____, _____, and J. Gimenez. 1953. Ann. Inst. Pasteur 84:814.
_____ and A.R. Prévot. 1954. Ann. Inst. Pasteur 86:722.
Ericsson, H., C. Högman, and K. Wickman. 1954. Scand. Jour. Clin. Lab. Invest. 6:23.
Flamm, H. 1956. Zent. f. Bakt. I. Orig. 166:498.
_____. 1957. Zent. f. Bakt. I. Orign. 168:261.
Henricksen, S.D. 1952. Jour. Gen. Microbiol. 6:318.
_____. 1958. Acta Path. Microbiol. Scand. 43:157.
Jones, F.S. and R.B. Little. 1923. Jour. Experimental Med. 38:139.
Kaffka, A. and R. Blödorn. 1959. Zent. f. Bakt. I. Orig. 174:594.
Lwoff, A. 1939. Ann. Inst. Pasteur 62:168.
Murray, R.G.E. and J.P. Truant. 1954. Jour. Bacteriol. 67:13.
Piéchaud, D., M. Piéchaud, and L. Second. 1951. Ann. Inst. Pasteur 80:97.
_____. 1956. Ann. Inst. Pasteur 90:517.
Scarlett, M. 1916. Ann. d'Oculistique 153:100.
Schaub, I. and F.D. Hauber. 1948. Jour. Bacteriol. 56: 379.

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LETTERS TO THE EDITOR

Nomenclatural standing of Names of Bacterial Genera Based on Descriptions of Impure Cultures. A draft proposal for an Opinion from the Judicial Commission was submitted to the members for consideration.

The draft proposal read:

"The name of a genus of bacteria is not validly published if the characterization of the genus when initially proposed was based upon impure or mixed cultures. Such generic name shall have no nomenclatural standing in bacteriology."

Dr. C.B. van Niel states his opposition to the approval of the Draft Opinion as formulated in the following statement:

"My dear Dr. Buchanan:

Herewith I am returning, with my negative vote, the ballot concerning the issuance of an opinion by the Judicial Commission on the non-validity of a generic name if this had been proposed on the basis of studies with impure cultures. I should like to use this opportunity to explain my position, which may seem to be at variance with my earlier vote on the Hallier-Billroth situation.

Let me begin by emphasizing that I believe to be fully aware of the implications of Brefeld's admonition that, unless the microbiologist works with pure cultures, his results are apt to be 'Penicillium glaucum and nonsense'. And I am confident that this criticism applies to the studies of Hallier, Billroth, and some other early workers.

That I disapprove of the present opinion is based on the consideration that it seems to me rather too sweeping. If this opinion should be accepted, a number of currently useful names should have to be invalidated. To cite a few examples: thus far no one has succeeded in isolating pure cultures of Thiospirillum, Thiovulum, Achromatium, or Gallionella. Nevertheless, these organisms are, as far as I can tell from experience, unmistakably recognizable. If these names were dropped as "having no nomenclatural standing in bacteriology", what is one to do in the meantime? Clearly they would be perpetuated until pure culture studies could be conducted; at such a time the investigator who had accomplished this feat would in any case be free to propose

his own notions on names and classification. Hence I can see no advantage in confusing the situation by issuing the opinion that was submitted to the members of the Judicial Commission.

Besides, if this opinion were accepted, is it not to be expected that a similar opinion with regard to species names should be in order? In that even Spirillum volutans and Spirochaeta plicatilis, to mention but two instances, should have to be dropped as "legitimate names", even though these organisms appear to be unambiguously determinable.

As you undoubtedly know, I am far from convinced that Winogradsky's many genera for certain entities among the purple sulfur bacteria (all based on studies with impure cultures) will stand up to critical examination. But it seems to me that the simplest way out of the dilemma is to settle down to a thorough comparative study of pure cultures, representing the various morphological types that Winogradsky differentiated, and on the basis of such material eventually propose a subdivision of the group more in keeping with the available information. This may well imply a proposal to reduce the number of "genera" to a much smaller number; but this could then be justified, whereas on the basis of the opinion now before us the names would become automatically inadmissible.

I hope that I have succeeded in making my position clear, and that I have not misinterpreted the intent of the opinion.

Yours most sincerely,

C. B. van Niel"

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PROPOSAL FOR A CHANGE IN THE NOMENCLATURE OF DIPLOCOCCUS PNEUMONIAE AND A COMPARISON OF THE DANISH AND AMERICAN TYPE DESIGNATIONS

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In some instances, certain tinctorial and cultural phenomena or fermentative reactions are sufficient for differentiation of bacteria; others require specific methods that have developed from the study of immunity. From the broad point of view of etiology, the drawing of such fine lines of division may be of minor significance, but from past experience with Diplococcus pneumoniae the fine points of differentiation have been of crucial importance in specific therapy (serum therapy) and of interest in importance epidemiologically. There is also merit in having simplified terminology to identify the elemental varieties of any organism. Names of species, for example, are binary combinations made up of the name of the genus followed by a single species appelation while names of subspecies are ternary combinations consisting of the name of the genus followed in order by the names of the species and subspecies.

In his paper, "Remarks on the Nomenclature and Classification of Bacteria", P.B. White (1) wrote the following: "It is reasonably clear that such an accepted genus as Salmonella, presenting types honored with specific names, is actually of the same order as Pneumococcus, treated usually as a single species enclosing numbered subtypes or varieties. Convenience, history, and the characters of the organisms themselves may favor this difference of treatment but the fact remains that the Salmonella type and the pneumococcus type are of equivalent natural status and are elementary species in the sense of de Vries, and that Salmonella and Pneumococcus are natural genera roughly defined by their R variants and by their basal proteins and polysaccharides.

The Committee might usefully reach a decision as to whether the taxonomic species should be established at the level of the elementary species or whether its size in different cases should continue to be dictated by convenience."

The subcommittee on Streptococci and Pneumococci of the International Bacteriological Nomenclature Committee discussed this problem at the Seventh International Microbiological Congress in Stockholm in 1958 and decided that the Pneumococcus was best regarded as a species within the genus Streptococcus. For the reasons stated above, however, the authors believe that the matter might be reconsidered and therefore propose that the taxonomic species be established for the pneumococcus at the level of the present species and that the serological types be regarded as species of the genus, Pneumococcus, in the same ways in which the serological Salmonella types are regarded as species of the genus Salmonella in the Kauffmann-White schema (2).

Nomenclature of the serological types of Pneumococcus has evolved along different lines. Bezançon and Griffon (3) in 1897 were the first to establish differences in serological behavior, using the serum of patients with pneumococcal infections. They concluded that from the standpoint of agglutination, several races of pneumococci existed and these behaved as though they were different microbes. Park and Williams (4) in 1905 classified Streptococcus mucosus (the present type 3) as a definite variety of Pneumococcus and Collins (5) in the same year also noted that Pneumococcus mucosus formed a distinct race and on the basis of absorption experiments was related more closely to Pneumococcus than to Streptococcus. In (1910) Neufeld and Haendel (6) demonstrated the full significant value of serological classification. They isolated and established Pneumococcus I as typical and one strain, "Franz", as atypical. Dochez and Gillespie (7) in 1913 divided the Pneumococcus into four groups; group I was the Pneumococcus I of Neufeld and Haendel, group II was identical with "Franz", group III was the specific, Pneumococcus mucosus, and group IV was a heterologous group. Lister (8) working with strains isolated in South Africa also published on the serological classification of pneumococci in 1913 and additional work was reported in 1916 (9) and 1917 (10). A total of 11 groups were described, A, B, C, D, E, F, G, H, J. K, and X. X in-

cluded unclassified strains. Lister's groups B, C, and E corresponded to Dochez and Gillespie's groups II, I and III.

In 1915 Avery (11) further subdivided group II into three subgroups IIA, IIB and IIX. The next year Olmstead (12) confirmed the classification of Pneumococcus into types I, II and III and then separated members of group IV into 12 groups some of which contained subgroups. Subsequently she (13) suggested that some of these groups were related to both group II and group IV but because of a closer relation to the latter should be classed as group IV. The same proposal was made by Clough (14) concerning Avery's subgroups IIA and IIB since members of these groups possessed relatively low virulence for animals and had been recovered from the mouths of normal persons. Stillman (15) in 1919 divided type II into 12 subgroups. Groups IIa and IIh were usually found in connection with disease in contrast with groups such as IIB, IIc, IIf, and IIm which were found in the mouths of normal people. In 1921 Griffith (16) compared strains he had isolated with strains sent to him from the United States. He found the three specific types I, II, and III and he separated group IV into other types including the American IIA and IIB. In a subsequent publication (17) he suggested that IIA be changed to IVA, and IIB to IVB. In 1926 Hintz (18) apparently unaware that type II had been subdivided, reported that this American type was not a distinct group. Among others, he identified Streptococcus mucosus as type III, although strains of this microorganism were encountered that gave atypical reactions. Robinson (19) in a study of immunological reactions of type IV pneumococci obtained during an epidemic described 4 groups in 1927. In 1928, Sugg, Gaspari, Fleming and Neill (20) and Harris, Sugg and Neill (21) described an atypical type III.

There were additional reports on the serological classification of the Pneumococcus during the years 1921 to 1932, but a series of studies by Cooper and her coworkers (22) (23) and (24) finally dispelled the confusion regarding the classification of Type IV and established 29 separate and definite types, including the atypical subtypes of other investigators. Table I.

In 1940 Kauffmann, Mørch and Schmith (25) reported new serological types, some of which were related to Cooper's

types. Such related types were labeled as subtypes and grouped together, for example, group 7 included types 7, 7A, 7B and 7C since these types had one or more capsular antigens in common. Kauffmann prepared a table of capsular antigens that were thought to be the most important for diagnosis. Like the "Kauffmann-White schema" of Salmonella antigens it was intended as a table for diagnostic purposes and not as a list of all antigens. The list was also useful in preparing type specific sera. For example, if a serum reacted with types 20, 31, 33A, 35A, 35C and 42, it was sufficient to absorb with only one of the types since each type contained the reacting antigen 20b.

In 1941 Walter and her coworkers (26) described seventeen new types and following the system of nomenclature of Kauffmann designated certain of the types as subtypes. Mørch (27) in 1942 also reported new types as subtypes, but the nomenclature of some of the types descibed by Walter were changed. In discussing these new types she stated, "It is to be emphasized once more that all the new types entered here in various groups are independent types, just like Cooper's types". Additional new types or subtypes were described by Mørch or Lund in 1944, 1950, 1957, (28) (29) (30) (31). Eddy (32) (33) in describing new types in 1944 employed the terminology of Cooper designating every type by a number regardless of its close relationship to another type. This choice was made for three reasons: 1) the lack of a satisfactory definition for a subtype, since some subtypes had a broader antigenicity than the major type while others did not, 2) disagreements of other workers as to the subtype designation, and 3) the fact that certain types were related not to one but to two or even more other types.

It was believed that this system of identifying each type with a number would prove advantageous for further study of type interrelationship since it is easier to recognize new types than to determine where they belong in the antigenic scheme. The use of a number for each type did not prevent related types from being grouped together wherever possible or from being changed from one group to another when it was useful to do so. During the period when typing was necessary for institution of specific serum therapy type identification was successfully simplified by the combination of Cooper's 32 types into six groups. Antigenic

formulas were unknown at the time so it is of interest that types 20 and 31, both of which contain the antigen 20b, were in different groups. Likewise types 18 and 23 which contain the 18b antigen were not in the same group. The usefulness of combinations of various type specific antiserum for different types was recognized by Eddy who proposed 14 combinations of her 75 types in 1944 (34). Based on quantitative studies of cross reactions in many immune sera, types most closely related were placed in the same group, with groups 1 and 2 containing the types that occurred with greatest frequency in the United States of America.

Representative strains of types or subtypes described by Lund after 1944 were studied by Eddy and there was agreement that these strains were antigenically different from other known types. Consistent with the system of identifying each type with a number, these strains were numbered by Eddy 76 to 81 respectively and because of the large number of types Arabic numerals were used instead of the Roman numbers that Cooper had employed.

In a study of representative American strains, Lund did not agree that types 47 and 62 which Eddy had found gave different cross reactions with types 29 and 52 were different. Both strains were classified as type 35A in the Danish system. This accounts for a total of 80 types or subtypes in the Danish list and 81 types in the American list.

Comparative terminologies of the two systems of nomenclature are shown in tables 2 and 3. It may be noted that with the one exception listed above there was agreement that the types or subtypes listed were different from other types. While Eddy's nomenclature is used in the United States, the Danish nomenclature is used in Europe. Large volumes of literature on the Pneumococcus have accumulated over the years and confusion would ensue if the nomenclature would be changed in one way or another. Therefore we propose that both systems of type designations be continued.

SUMMARY

It is proposed that the Diplococcus pneumoniae be considered as the genus Pneumococcus and the serological types as species. A brief history of the nomenclature of pneumococcal types and correlation of the Danish and American type designations are given.

Table 1. Correlation of some of the present Danish and American types with earlier type epithets.

Present Danish and American types	Earlier type epithets
1	I (Neufeld and Haendel) C (Lister)
2	Franz (Neufeld and Haendel) B (Lister) II (Dochez and Gillespie)
3	Streptococcus mucosus (Parke and Williams) Pneumococcus mucosus (Collins) E (Lister) III Dochez and Gillespie
4	Pneumococcus 10 (Griffith) IVB (Robinson) IV (Cooper)
5	11A (Avery) IVA (Clough) IVA (Griffith) V (Cooper)
6	11B (Avery) IVB (Clough) IVB (Griffith) VI (Cooper)
8	Atypical III (Sugg) and (Harris) IVA (Robinson) VII (Cooper)
15	Pneumococcus 98 (Griffith) XV (Cooper)
21	Pneumococcus 160 (Griffith) XXI (Cooper)
22	Pneumococcus 41 (Griffith) XXII (Cooper)

Table 2. Correlation of the Danish and American type designations with the antigenic formulas according to Kauffmann and Lund.

Denmark	Antigenic formulas	USA	Denmark	Antigenic formulas	USA
1	1a	1	20	20a, 20b, 7g	20
2	2a	2	21	21a	21
3	3a	3	22	22a, 22b	22
4	4a	4	22A	22a, 22c	63
5	5a	5	23	23a, 23b, 18b	23
6	6a, 6b	6	23A	23a, 23c, 15c	46
6A	6a, 6c	26	23B	23a, 23b, 23d	64
7	7a, 7b	51	24	24a, 24b, 24d, 7h	24
7A	7a, 7b, 7c	7	24A	24a, 24c, 24d	65
7B	7a, 7d, 7e, 7h	48	24B	24a, 24b, 24e, 7h	60?
7C	7a, 7d, 7f, 7g, 7h	50	25	25a, 25b	25
8	8a	8	27	27a, 27b	27
9A	9a, 9c, 9d	33	28	28a, 28b, 16b, 23d	28
9L	9a, 9b, 9c, 9f	49	28A	28a, 28c, 23d	79
9N	9a, 9b, 9e	9	29	29a, 29b, 13b	29
9V	9a, 9c, 9d, 9g	68	31	31a, 20b	31
10	10a, 10b	10	32	32a, 27b	32
10A	10a, 10c, 10d	34	32A	32a, 32b, 27b	67
11	11a, 11b, 11e, 11g	11	33	33a, 33b, 33d	70
11A	11a, 11c, 11d, 11e	43	33A	33a, 33b, 33d, 20b	40
11B	11a, 11b, 11f, 11g	76	33B	33a, 33c, 33d, 33f	42
11C	11a, 11b, 11c, 11d, 11f	53	33C	33a, 33c, 33e	39
12	12a, 12b	12	34	34a, 34b	41
13	13a, 13b	13	35	35a, 35b, 34b	35
14	14a	14	35A	35a, 35c, 20b	47, 62
15	15a, 15b, 15c, 15f	15	35B	35a, 35c, 29b	66
15A	15a, 15c, 15d, 15g	30	35C	35a, 35c, 20b, 42a	61
15B	15a, 15b, 15d, 15e, 15h	54	36	36a, 9e	36
15C	15a, 15d, 15e	77	37	37a	37
16	16a, 16b, 11d	16	38	38a, 25b	71
17	17a, 17b	17	39	39a, 10d	69
17A	17a, 17c	78	40	40a, 7g, 7h	45
18	18a, 18b, 18c, 18f	18	41	41a, 41b	38
18A	18a, 18b, 18d	44	41A	41a	74
18B	18a, 18b, 18e, 18g	55	42	42a, 20b, 35c	80
18C	18a, 18b, 18c, 18e	56	43	43a	75
19	19a, 19b, 19d	19	44	44a, 44b, 12b	81
19A	19a, 19c, 19d	57	45	45a	72
19B	19a, 19c, 19e, 7h	58	46	46a, 44b	73
19C	19a, 19c, 19f, 7h	59	47	47a, 35a, 35b	52

Table 3. Correlation of the American and Danish type designations.

USA	Denmark	USA	Denmark
1	1	41	34
2	2	42	33B
3	3	43	11A
4	4	44	18A
5	5	45	40
6	6A	46	23A
7	7A	47	35A
8	8	48	7B
9	9N	49	9L
10	10	50	7C
11	11	51	7
12	12	52	47
13	13	53	11C
14	14	54	11B
15	15	55	18B
16	16	56	18C
17	17	57	19A
18	18	58	19B
19	19	59	19C
20	20	60	24B?
21	21	61	35C
22	22	62	35A
23	23	63	22A
24	24	64	23B
25	25	65	24A
26	6B	66	35B
27	27	67	32A
28	28	68	9V
29	29	69	39
30	15A	70	33
31	31	71	38
32	32	72	45
33	9A	73	46
34	10A	74	41A
35	35	75	43
36	36	76	11B
37	37	77	15C
38	41	78	17A
39	33C	79	28A
40	33A	80	42
		81	44

REFERENCES

1. White, P.B. (1957) Report of Proceedings of the Second International Congress for Microbiology. (London) 2:547.
2. Salmonella Subcommittee. (1934) J. of Hyg. 34:334.
3. Bezançon, F. and V. Griffon. (1897) Compt. rend. Soc. de biol. 49:579.
4. Park, W.H. and A.W. Williams. (1905) J. Exp. Med. 7:403.
5. Collins, K.R. (1905) J. Exp. Med. 7:420.
6. Neufeld, F. and L. Haendel. (1910) Arb. c. d. k. Gsndhts. 34:293.
7. Dochez, A.R. and L.J. Gillespie. (1913) Jour. Amer. Med. Assoc. 61:727.
8. Lister, F.S. (1913) Publication of South African Institute for Medical Research, No. 2, 106.
9. ____. (1916) Publication of South African Institute for Medical Research, No. 8, 1.
10. ____. (1917) Publication of South African Institute for Medical Research, No. 10, 1.
11. Avery, O.T. (1915) J. Exp. Med. 22:804.
12. Olmstead, M. (1916) Proc. Soc. Exper. Biol. and Med. 14:29.
13. ____. (1917) J. Immunol. 2:425.
14. Clough, M.C. (1917) J. Johns Hopkins Hosp. 28:306.
15. Stillman, E.G. (1919) J. Exp. Med. 29:251.
16. Griffith, F. (1921) Lancet 2:226.
17. ____. (1922) Great Britain Ministry of Health Report on Public Health and Medical Subjects (London) No. 13, 20. His Majesty's Stationery Office.
18. Hintze, K. (1926) Centralbl. f. Bakt. 1 Abt., Orig. 99:419.
19. Robinson, G.H. (1927) J. Inf. Dis. 41:417.
20. Sugg, J.Y., E.L. Gaspari, W.L. Fleming and J.M. Neill. (1928) J. Exp. Med. 47:917.
21. Harris, A.L., J.Y. Sugg, and J.M. Neill. (1928) J. Exp. Med. 47:933.
22. Cooper, G.M., L. Mishulow and N.E. Blanc. (1921) J. Immunol. 6:25.
23. ____, M. Edwards and C. Rosenstein. (1929) J. Exp. Med. 49:461.

24. ____, C. Rosenstein, A. Walter and L. Peizer. (1932) J. Exp. Med. 55:531.
25. Kauffmann, F., E. Mørch and K. Schmith. (1940) J. Immunol. 39:397.
26. Walter, A. W., V. H. Guevin, M. W. Beattie, H. Y. Colter and H. B. Bucca. (1941) J. Immunol. 41:279.
27. Mørch, E. (1942) J. Immunol. 43:177.
28. ____. (1944) Acta Pathologica 21:142.
29. ____. (1944) Acta Pathologica 21:747.
30. Lund, E. (1950) Acta Pathologica 27:720.
31. ____. (1957) Acta Pathologica 40:425.
32. Eddy, B. E. (1944) Publ. Health Repts. 59:449.
33. ____. (1944) Publ. Health Repts. 59:451.
34. ____. (1944) Publ. Health Repts. 59:485.

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RECOGNITION OF SEROTYPES IN THE FAMILY ENTEROBACTERIACEAE AS SPECIES

Preliminary Statement

Editorial Board[1]
Judicial Commission

The following preliminary statement has been submitted to the Judicial Commission in conformity with the request of Dr. Kauffmann (1959a, 1959b).

- - - - - -

Dr. F. Kauffmann has proposed that each serotype recognized in the bacterial family Enterobacteriaceae be regarded as a species, that genera be defined as including a group of related species, and has requested an OPINION on these two proposals. This request apparently calls for an examination of the authority of the Judicial Commission to issue Opinions relating to problems of taxonomy (classification) as contrasted to problems of nomenclature.

The following background statement and draft proposal has been prepared by the Editorial Board of the Judicial Commission for submission to you as a member of the Judicial Commission for approval, disapproval, or emendation.

Draft Proposal for Opinion

Dr. F. Kauffmann has submitted the following request:

"The Judicial Commission is requested to give an Opinion on the following proposals:

1. The species in the Enterobacteriaceae are the established serotypes.
2. The genera are groups of related species."

In support of this proposal Dr. F. Kauffmann has published two papers (1959a, 1959b). He concludes that the established serotypes in the genus Salmonella constitute elementary species and should be recognized as species. He extends this concept to all serotypes recognized in the family Enterobacteriaceae.

[1]R. E. Buchanan, S. T. Cowan and W. A. Clark.

Is the Judicial Commission (under the directives of the International Committee on Bacteriological Nomenclature and of the International Association of Microbiological Societies) authorized to issue OPINIONS that do not relate directly and primarily to problems of nomenclature?

The functions of the Judicial Commission are detailed in "Chapter 4, Provisions for Exceptions to the Rules and for the Interpretation and Modification of Rules", International Code of Nomenclature of Bacteria and Viruses, 1958. pp. 131-134. The pertinent paragraph (No. (2)) gives as one of the Commission's functions

> "(2) To consider all requests for Opinions relative to the interpretation of the Principles, Rules, Recommendations and Provisions of the International Code of Nomenclature of the Bacteria and Viruses where applications are doubtful."

The Bacteriological Code is concerned with nomenclature, with names given to the several ranks of taxa and with names given to the several taxa.

Principle 1 states:

> "The essential points in nomenclature are
>
> (1) To aim at fixity of names;
>
> (2) To avoid or to reject the use of names which may cause error or ambiguity or throw science into confusion."

Principle 5 states:

> "Nomenclature deals with:
>
> (1). The terms which denote the categories of taxa (taxonomic groups or units, such as species, genus, family) and the relative ranks of these categories.
>
> (2). The names which are applied to the individual taxa (taxonomic groups), such as Bacillus subtilis, Streptococcus, Spirillaceae, Spirochaetales."

Principle 9 states:

> "Each order or taxon of lower rank with a given circumscription, position and rank can bear only one correct name, . . . "

There is no provision in the Code for determining the circumscription, description, position or rank of any or-

ganism or group of organisms (i.e. of any taxon). Only after the taxon (species, genus, etc.) has been defined does nomenclature come into play. The nomenclator applies the rules of nomenclature to determine the correct name of each taxon when once its circumscription, description and rank have been fixed by an investigator. The circumscribing and defining of taxa is a problem of taxonomy, of classification, of study of relationships, not of nomenclature. There are no fixed rules governing the defining of taxa in biology. This does not mean that taxonomy must be chaotic. In practice there comes essential agreement among taxonomists who are specialists in the respective taxa. Determinative bacteriology has made great advances, but classification must remain flexible as new discoveries are made and techniques developed.

The International Committee on Bacteriological Nomenclature has as one of its functions:

> "To authorize or appoint special subcommittees of experts to consider and report on the classification of special groups of microorganisms and other phases of their taxonomy, to sponsor one or more sessions of a Section on Taxonomy and Classification at each International Congress at which these reports of subcommittees may be presented and discussed; to receive and recommend for publication the reports of these subcommittees, and to refer to the Judicial Commission any special problems that have been raised or recommendations that have been made respecting nomenclature."

The International Committee stimulates discussion of taxonomy by the subcommittees appointed, the subcommittee reports may be accepted by the Committee, but there is no provision for approval of their taxonomic conclusions. All recommendations relative to Nomenclature are referred to the Judicial Commission.

The Subcommittees on Taxonomy are made up of individuals who are actively working on the circumscriptions and descriptions of the several taxonomic groups with which the subcommittee is concerned. The taxonomic recommendations of these subcommittees and of monographers of special groups are important and in general are widely accepted.

But by the very nature of the problems involved all such recommendations are subject to change with advancing knowledge and better techniques of study. There have not been, and probably cannot be, any set of rules adopted which can govern descriptions. Taxonomy, determination of taxon relationships, classification, cannot be static. Codes of nomenclature cannot govern. General acceptance of classifications is usually based upon consensus of opinion among experts.

The rules of nomenclature throughout biology recognize that names must be given to the various taxa as they are defined, the names to be applied should be as stable as is consistent with advancing knowledge of inter-taxon relationships. Throughout biology there is substantial agreement that nomenclatural rules are essential; such rules have international sponsorship in each of the biological disciplines.

The Editorial Board submits the following draft proposal of an OPINION to the members of the Judicial Commission for approval, rejection, or emendation.

Draft Opinion

1. The definition, circumscription and description of taxa (taxonomic groups), study of their relationships and their orderly systematic arrangement constitute in large part the content of taxonomy. The definitions of taxa must change with advancing knowledge. There are no rules which govern the definitions of the several taxa.

2. The name to be applied to a taxon when once it is defined is determined by application of rules set down in codes of nomenclature approved by international agreement in each of the biological disciplines.

3. The International Code of Nomenclature of Bacteria and Viruses recognizes clearly the distinction between describing the several bacterial taxa and determining their circumscriptions and arranging them on the basis of relationships on the one hand, and on the other determining the correct name for each taxon when once defined (the function of nomenclature). The International Codes provide rules for application of names to defined taxa, but do not lay down regulations for their definition. The Judicial Commission is empowered to formulate and issue OPINIONS relative to problems of nomenclature, but has no power

to determine definitions and circumscriptions of individual taxa.

4. Dr. Kauffmann proposes that the established serotypes in the family Enterobacteriaceae be recognized as species. Essentially the request is that the description and circumscription of all species be fixed in the family Enterobacteriaceae.

5. Dr. Kauffmann's first request has to do with taxonomy, the criteria for species characterization in the Enterobacteriaceae, and not with nomenclature. The Judicial Commission is authorized to issue opinions only on nomenclatural problems, and therefore has no jurisdiction.

6. The second request of Dr. Kauffmann is that in the family Enterobacteriaceae there be approval of the statement "The genera are groups of related species."

The Judicial Commission agrees that not only in the family Enterobacteriaceae but throughout bacteriology the term genus may be defined as a group of related species (in a monotypic genus there may be a single species). Principle 7 of the Bacteriological Code reads in part:

"The terms which denote the rank of taxonomic groups (taxa) are defined as follows:

(a) Every individual is treated as belonging to a number of categories of consecutive rank and consecutively subordinate; of these the species is the basic one. The principal categories in ascending sequence are species, genus, family, order, class, division."

Inasmuch as the second request of Dr. Kauffmann conforms to Principle 7 and is consonant with the use of the term "genus" throughout the Bacteriological Code, the Judicial Commission concludes that an official OPINION is not required.

Addendum

In a personal letter to the chairman, Dr. Kauffmann writes as follows:

"I would agree with the Draft Opinion if a sentence is added that this problem is transferred to the Enterobacteriaceae Subcommittee which should make a proposal on the taxonomy of Enterobacteriaceae, especially on the species-definition."

In accordance with Dr. Kauffmann's request, the Judicial

Commission will be asked to vote upon Dr. Kauffmann's proposal that the problem be referred for recommendation to the Subcommittee on Enterobacteriaceae.

References

Kauffmann, F. 1959a. On the Principles and Nomenclature of Enterobacteriaceae. Internat. Bull. Bact. Nomen. and Taxon. 9:1-6.

____. 1959b. Definition of genera and species of Enterobacteriaceae. id, 9:7-8.

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STATUS OF THE GENERIC NAME *MYCOBACTERIUM* LEHMANN AND NEUMANN[1]

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Mycobacterium Lehmann and Neumann (1896, 363) has been commonly accepted as the name of a genus of acid-fast bacteria from the time of its proposal; its legitimacy, however, has not gone unchallenged. Vuillemin (1913, 527) rejected *Mycobacterium* Lehmann and Neumann 1896 as a later synonym of *Sclerothrix* Metschnikoff 1888, placing the latter in a list of generic names which he proposed for conservation; Enderlein (1917, 315; 1925, 259) likewise rejected *Mycobacterium* as a later synonym of *Sclerothrix*. Buchanan (1918, 56; 1925, 387) noted the priority of *Coccothrix* Lutz 1886 over *Mycobacterium*. The nomenclatural status of the generic name *Mycobacterium* Lehmann and Neumann requires review.

DISCUSSION

Koch (1882), in his classical paper on the etiology of tuberculosis, used several vernacular names to designate the causal organism (viz. Tuberkel-Virus, Tuberkelbacterien and Tuberkelbacillen); however in this paper he proposed neither a generic name nor a species name in the form of a (Linnaean) binary combination.

Zopf (1883, 67) proposed the first species name, *Bacterium tuberculosis*, for Koch's tubercle bacillus.

Klein (1884b, 34) transferred the organism to the genus *Bacillus* Cohn, proposing the name *Bacillus tuberculosis* (Koch) (sic) Klein.

Koch (1884) published a second paper on the etiology of tuberculosis in which he again used only vernacular names when referring to the causative organism of tuberculosis.

Lutz (1886, 98 and 99) placed both the leprosy bacillus and the tubercle bacillus in a new genus for which he pro-

[1] Journal Paper No. J-3749 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 151.

posed the name Coccothrix. The pertinent statements by Lutz are:

> . . . Für den Lepraspaltpilz und verwandte Organismen schlage ich vor eine Abteilung der Coccotrichaceen mit dem Genus Coccothrix zu bilden. Letzteres ist folgendermassen zu definieren:
>
> Kleine, runde, kokkenähnliche Zellen, die sich ohne Mitbeteiligung der Zellmembran nur in einer Richtung teilen und daher einzeln oder in Reihen getroffen werden. Dieselben sind von den gedehnten, allmählich gallertig verquellenden, Zellhäuten überzogen; zwischen den einzelnen Zellen befinden sich Interstitien, welche deren Durchmesser and Grösse übertreffen. Durch Färbung der innersten Schichten der membranösgallertigen Hülle entstehen Bilder, welche wie auf Fäden angereihte Perlen oder wie Stäbchen aussehen. Es finden sich ausserdem grössere zum Teil ovale und doppelt konturierte Zellen, teils frei, teils am Ende der Zellreihen.
>
> In dieses Genus ist vorderhand mit Sicherheit der Lepra- und Tuberkelpilz einzureihen.

Erwin F. Smith (1905, 172 and 174) rejected the generic name Cocothrix (sic) Lutz because of its similarity to Cocothrichium (sic) Link. Vuillemin (1913, 527) designated Koch's tubercle bacillus as the type species of the genus Coccothrix Lutz but rejected this generic name because of the likelihood of confusion with Coccotrichum Wallroth (see Bact. Code, 1958, Rule 27). According to Vuillemin:

> Lutz avait créé 1886 un genre Coccothrix ayant pour type le Bacille tuberculeux de Koch. Il est à craindre que ce nom, resté peu connu d'ailleurs, provoque une confusion avec Coccotrichum Wallroth. Noun préférons Sclerothrix Metchnikoff 1888. Les noms postérieus, tels que Mycobacterium sont des synonymes superflus.

However, even though Coccothrix has the same etymology

as Coccothrichium and Coccotrichum, orthographically it differs substantially from both of these and therefore does not cause confusion. Coccothrix is neither an orthographic variant nor a homonym of either Coccothrichium or Coccotrichum (Rule 27).

Lutz did not use his new generic name in a binary combination for either of the two species he included in his genus, nor did he cite a previously and effectively published description of either of these species under another name. Therefore, according to Opinion 20(4) (Internatl. Bull. Bact. Nomen. and Taxon. 8:162 (1958)), the generic name Coccothrix Lutz was not validly published even though later authors (e.g. Unna 1887, 11; Enlows 1920, 31; Buchanan 1925, 275) have cited Coccothrix Lutz and in some cases have ascribed (incorrectly) the combinations Coccothrix leprae and C. tuberculosis to Lutz (also see DeToni and Trevisan 1889, 944 and 943; Vuillemin 1913, 527; Bergey et al. 1934, 536; Hauduroy et al. 1937, 291 and 1953, 327 and 335; Reed 1939, 810 and 1948, 877; Krassilnikov 1941, 109 and 107 and 1949, 180 and 179; Hanks 1948, 882).

Metschnikoff (1888, 70) proposed the name Sclerothrix for a genus to include S. kochii, the tubercle bacillus of Koch, which becomes the type species of the genus by monotypy. However the generic name Sclerothrix Metschnikoff is illegitimate as a later homonym of the algal generic name Sclerothrix Kützing 1849, 319 (Rule 24d). It should be noted here that the earliest legitimate specific epithet for the type species of this genus is tuberculosis (from the basionym Bacterium tuberculosis Zopf 1883, 67), and the specific epithet kochii is therefore illegitimate (Rule 24b). The species name Sclerothrix kochii was corrected to S. tuberculosis by Vuillemin (1913, 527).

Lehmann and Neumann (1896, 363) proposed the name Mycobacterium for a genus comprised of three species: "Mycobacterium tuberculosis (R. Koch) Lehm. et Neum.," "Mycobacterium tuberculosis avium (Maffucci). Lehm. et Neum." and "Mycobacterium leprae. Armauer Hansen. (Lehm et Neum.)." Winslow et al. (1917, 554) were the first to designate a type species for this genus - Mycobacterium tuberculosis (Koch)(sic) Lehmann and Neumann. Lehmann and Neumann (1896, 363) incorrectly cited "Bacillus tuberculosis Koch" 1884 as the basionym of Mycobacterium tuberculosis. As mentioned previously, the

first binary combination proposed for this organism was Bacterium tuberculosis Zopf 1883. The type species of the genus Mycobacterium is correctly cited as Mycobacterium tuberculosis (Zopf) Lehmann and Neumann.

Lehmann and Neumann (1899, 114) later recognized the fact that Metschnikoff (1888, 70) had earlier proposed the generic name Sclerothrix for a monotypic genus to include S. kochii, the tubercle bacillus of Koch. However they defend the name Mycobacterium and reject the priority of Sclerothrix Metschnikoff in the following statement:

> . . . Wir hatten diesen Namen [Sclerothrix und S. kochii] sofor acceptiert, wenn wir ihn gekannt hätten, glauben aber nach den Regeln der botan. Nomenclatur jetzt bei unserem Namen bleiben zu sollen, da Metschnikoff nur einen bedingungsweisen Vorschlag machte, sein neues Genus nicht streng definierte, selbst nie von dem neuen Namen Gebrauch machte und wir einmal selbst einen Namen gegeben haben.

Although the priority of the generic name Sclerothrix Metschnikoff cannot be dismissed on the basis of the arguments just quoted, Sclerothrix Metschnikoff 1888 is illegitimate as a later homonym of the algal generic name Sclerothrix Kützing 1849. Consequently, Mycobacterium Lehmann and Neumann is the first validly published and legitimate name for the genus which has as its type species the tubercle bacillus of Koch (Bacterium tuberculosis Zopf 1883, 67).

Thirteen years after Lehmann and Neumann had proposed the name Mycobacterium, Orla-Jensen (1909, 329) proposed Mycomonas as a substitute name for Mycobacterium as follows:

> An die Familie Actinomycetes schliessen sich nach Lehmann und Neumann die Gattungen Corynebacterium und Mycobacterium, welche ich lieber Corynemonas und Mycomonas nenne.

Being a subsitute name, Mycomonas Orla-Jensen is illegitimate (rule 23) and becomes a later synonym of Mycobacterium Lehmann and Neumann. Although Orla-Jensen did

not name or indicate any species as belonging to his genus, according to Rule 9c (3) (d) the publication of a new generic name as an avowed substitute for an earlier one does not change the type of the genus. Therefore the type species of the genus Mycomonas Orla-Jensen is the same as that of Mycobacterium Lehmann and Neumann, i. e. Mycobacterium tuberculosis (Zopf) Lehmann and Neumann.

Battaglia (1938, 166) use "Eumyces tuberculosis" as the title of a publication wherein he contended that the characteristics of the tubercle bacillus are such that it should be included among the "Eumycètes" (the true fungi). "Eumyces," which does not appear in the body of Battaglia's paper, was not proposed as a generic name, hence it has no standing in nomenclature. Battaglia apparently used "Eumyces" as the obvious singular form of the plural "Eumycètes," and "Eumyces tuberculosis" probably was intended to mean "the tuberculosis eumycete." Reed (1948, 876 and 877) incorrectly cited "Eumyces Battaglia" as a synonym of Mycobacterium Lehmann and Neumann and "Eumyces tuberculosis Battaglia" as a synonym of "Mycobacterium tuberculosis (Schroeter) Lehmann and Neumann." Hauduroy et al. (1953, 335) incorrectly cited "Eumyces tuberculosis Battaglia" as a synonym of "Mycobacterium tuberculosis var. hominis (Schroeter) Lehmann and Neumann."

CONCLUSIONS

1. Coccothrix Lutz (1886, 98) was the first name proposed for a genus having Koch's tubercle bacillus designated as its type species. Coccothrix Lutz was not validly published and has no standing in nomenclature.

2. Sclerothrix Metschnikoff (1888, 70) was a validly published generic name but, as a later homonym of Sclerothrix Kützing (1849, 319), is an illegitimate earlier synonym of Mycobacterium Lehmann and Neumann (1896, 363).

3. Mycobacterium Lehmann and Neumann (1896, 363) is the first validly published and legitimate name of a genus having Koch's tubercle bacillus (Bacterium tuberculosis Zopf 1883, 67) as its type species.

4. Mycomonas Orla-Jensen (1909, 329) was a validly published generic name but is illegitimate as a later synonym of Mycobacterium Lehmann and Neumann (1896, 363).

The type species of this genus is the same as that of Mycobacterium, i.e. Mycobacterium tuberculosis (Zopf) Lehmann and Neumann.

5. "Eumyces" Battaglia (1938, 166) was not proposed as a generic name and does not have standing in nomenclature; Reed (1948, 876) incorrectly cited "Eumyces Battaglia" as a generic name synonymous with Mycobacbacterium Lehmann and Neumann.

6. The synonymy of the generic name Mycobacterium may be indicated as follows:

Mycobacterium Lehmann and Neumann 1896, 363.

(Coccothrix Lutz 1886, 98; Sclerothrix Metschnikoff 1888, 70 (not Sclerothrix Kützing 1843, 229; not Sclerothrix Kützing 1849, 319); Mycomonas Orla-Jensen 1909, 329.)

REFERENCES

Battaglia, M. 1938. Eumyces tuberculosis. Società Internaz. di Microbiologia, Bollettino della Sez. Italiana. 10:166-171.

Bergey, David H., Robert S. Breed, Bernard W. Hammer, Frank M. Huntoon, E. G. D. Murray and Francis C. Harrison. 1943. Bergey's Manual of Determinative Bacteriology. The Williams and Wilkins Co., Baltimore. 4th ed. pp. 1-664.

Buchanan, R.E. 1918. Studies in the Nomenclature and Classification of the Bacteria. V. Subgroups and Genera of the Bacteriaceae. Jour. Bact. 3:27-61.

____. 1925. General Systematic Bacteriology. The Williams and Wilkins Co., Baltimore. pp. 1-597.

DeToni, J.B. and V. Trevisan. 1889. Schizomycetaceae Naeg., in Saccardo, P.A. Sylloge Fungorum. Patavii. 8:923-1087.

Enderlein, Günther. 1917. Ein neues Bakteriensystem auf vergleichend morphologischer Grundlage. Sitzber. d. Gesellsch. Naturf. Freunde zu Berlin. Jahrgang 1917. pp. 309-319.

____. 1925. Bakterien - Cyclogenie. Walter de Gruyter and Co., Berlin and Leipzig. pp. 1-390.

Enlows, Ella M.A. 1920. The Generic Names of Bacteria. Treasury Dept. U.S.P.H. Service. Government Printing Office, Washington, D. C. Hygienic Laboratory - Bull. No. 121:1-115.

Hanks, John H. 1948. Mycobacterium leprae and M. lepraemurium, in Breed et al., Bergey's Manual of Determinative Bacteriology. The Williams and Wilkins Co., Baltimore. 6th ed. pp. 881-883.

Hauduroy, Paul, G. Ehringer, Ach. Urbain, G. Guillot and J. Magrou. 1937. Dictionnaire des Bactéries Pathogènes. Masson and Co., Paris. pp. 1-597.

____, ____, G. Guillot, Magrou, A.-R. Prévot, Rosset and Urbain. 1953. Dictionnaire des Bactéries Pathogènes. Masson and Co., Paris. 2nd ed. pp. 1-692.

International Code of Nomenclature of the Bacteria and Viruses. 1958. Iowa State College Press, Ames. pp. 1-186.

Klein, Edward Emanuel. 1884a. Micro-organisms and Disease. The Practitioner. 32:170-186, 241-264, 321-352, 401-426.

____. 1884b. Micro-organisms and Disease (continued from vol. xxxii. p. 426.). The Practitioner. 33:21-40, 81-112, 161-180, 241-254.

Koch, Robert. 1882. Die Aetiologie der Tuberculose. Berliner Klinische Wochenschrift. 19:221-230.

____. 1884. Die Aetiologie der Tuberkulose. Mittheilungen aus dem Kaiserlichen Gesundheitsamte. 2:1-88.

Krassilnikov, N.A. 1941. Guide to the Actinomycetes. Izd. Akad. Nauk, U.S.S.R., Moscow. pp. 1-148.

____. 1949. Guide to the Bacteria and Actinomycetes. Izd. Akad. Nauk, U.S.S.R., Moscow. pp. 1-830.

Kützing, Friedrich Traugott. 1843. Phycologia Generalis (oder Anatomie, Physiologie und Systemkunde der Tange). F.A. Brockhaus, Leipzig. pp. 1-458.

____. 1849. Species Algarum. F.A. Brockhaus, Leipzig. pp. 1-922.

Lehmann, K.B. and Rudolf Neumann. 1896. Lehmann's Med. Handatlanten, X. Atlas und Grundriss der Bakteriologie und Lehrbuch der speciellen bakteriologischen Diagnostik. J.F. Lehmann, München. 1 Aufl. 2:1-448.

____, ____. 1899. Lehmann's Medecin. Handatlanten, X. Atlas und Grundriss der Bakteriologie und Lehrbuch der speziellen bakteriologischen Diagnostik. J.F. Lehmann, München, 2 Aufl. 2:1-495.

Lutz, Adolph. 1866. Zur Morphologie des Mikroorganismus der Lepra. Dermatologische Studien. 1:77-100.

Metschnikoff, Elias. 1888. Ueber die phagocytäre Rolle der Tuberkelriesenzellen. Arch. f. path. Anat. u. Physiol. 113:63-94.

Orla-Jensen, S. 1909. Die Hauptlinien des naturlichen Bakterien-systems. Cent. f. Bakt., II Abt. 22:305-346.

Reed, Guilford B. 1939. Genus Mycobacterium Lehmann and Neumann, in Bergey et al., Bergey's Manual of Determinative Bacteriology. The Williams and Wilkins Co., Baltimore. 5th ed. pp. 809-827.

____. 1948. Family Mycobacteriaceae Chester, in Breed et al., Bergey's Manual of Determinative Bacteriology, The Williams and Wilkins Co., Baltimore. 6th ed. pp. 875-891.

Unna, P.G. 1887. Die Rosaniline und Pararosaniline. (Eine Bakteriologische Farbenstudie.) Dermatologische Studien. 4:1-73.

Vuillemin, Paul. 1913. Genera Schizomycetum. Annales Mycologici (Berlin). 11:512-527.

Winslow, C.-E.A., Jean Broadhurst, R. E. Buchanan, Charles Krumwiede, Jr., L.A. Rogers and George H. Smith. 1917. The Families and Genera of the Bacteria. Preliminary Report of the Committee of the Society of American Bacteriologists on Characterization and Classification of Bacterial Types. Jour. Bact. 2:505-566.

Zopf, W. 1883. Die Spaltpilze. Eduard Trewendt, Breslau. pp. 1-100.

ERRATUM

TAYLOR, JOAN. Why Christen a Salmonella? Internatl. Bull. Bact. Nomen. and Taxon 9(4):159. 1959.

The first paragraph of this article should read:

The Enterobacteriaceae Subcommittee of the Nomenclature Committee of the International Association of Microbiological Societies has published the Minutes agreed to at its last meeting (1958), in which the concept that the family Enterobacteriaceae should be divided into large groups comparable, but not identical, with genera, and smaller groups down to serotypes, comparable, but not identical, with species and subspecies, needs careful consideration in order to understand the arguments in favour of the use of the term "groups" rather than the terms "genus" and "species," suggested by Kauffmann (1959).